Automated Machine Guidance

Caltrans - Division of Construction

Office of Construction Engineering

Presentation Outline

- Definitions
- Guidance/Control
- Changing Role of Contractor
- Changing Role of Surveyor
- Changing Role of the Inspector
- Caltrans AMG Implementation

Definitions

- **Automated Machine Guidance** (AMG): A technology that uses positioning devices, singly or in combination, such as Global Positioning Systems (GPS), total stations, or rotating laser levels to determine and control the real time position of construction equipment using onboard computer equipment. AMG is used in reference to both machine guidance and machine control.

Definitions

- **Digital Terrain Model** (DTM): A 3-dimensional model representing the original ground before job site activities start.

- **Digital Design Model** (DDM): A 3-dimensional model consisting of roadway design alignments, profiles, and cross sections representing the finished grade.

- **Digital Construction Model** (DCM): A 3-dimensional model developed by the Contractor to use with specific AMG equipment.

Definitions

- **Machine Guidance:** A computerized system that uses sensor output and a 3D design model to provide the equipment operator a visual indicator of the position of the cutting edge (blade, bucket, screed, etc.) relative to the design surface being constructed. The operator is in complete control of all parts of the equipment.

Definitions

- **Machine Control:** A computerized system where the cutting edge (blade, bucket, screed, etc.) is fully controlled by automation. The system is connected to and controls the hydraulics while the operator simply drives the equipment and manages the automation.

Guidance System

- Provides the interface between engineering design and the equipment operator

Guidance System

- ~~Standard Stakes~~ Fewer stakes
- ~~String Lines~~
- ~~Sonic Sensors~~
- ~~Laser levels~~
- GPS
- Total Stations
- GPS w/Lasers

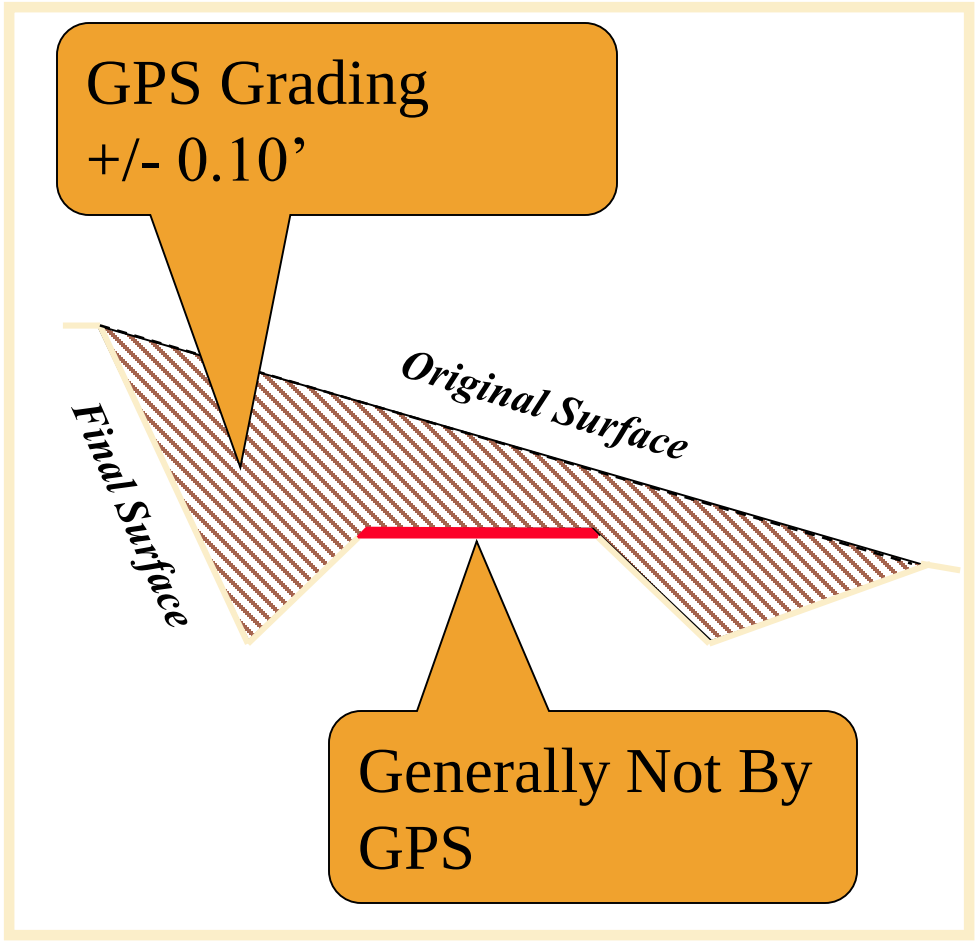
GPS Guidance

- GPS based machine guidance
- GPS provides near exact position of equipment in “real time”
- Display indicates position of machine relative to design surface
- Equipment operator fully controls equipment using visual information from display

Machine Control By GPS

- GPS provides near exact position of equipment in “real time”
- Position of the equipment cutting edge is computed against the 3D design model
- The onboard computer directly controls the hydraulics which in turn adjusts the cutting edge to match the design surface
- The equipment operator drives the equipment and manages the automation

Guidance/Control by GPS



Control by Total Station

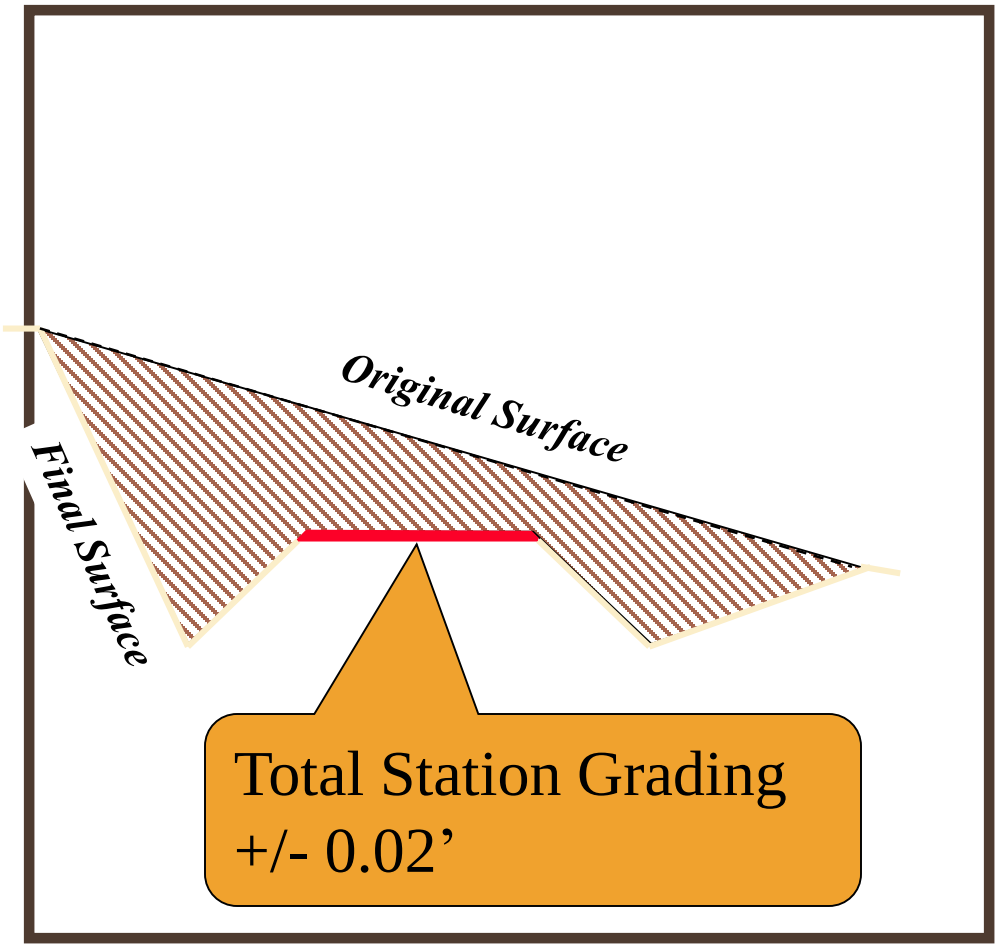
- Robotic motorized total stations track a prism mounted on a machine

Control by Total Station

- Information from the prism position is sent to the machine, which controls the hydraulics accordingly to adjust the cutting edge.

Control by Total Station

Control by Total Station



Changing Role of Contractor using AMG

- Fewer stakes required
- No grade checker required
- Records data for quality control
- Records data for volume computation

Changing Role of Surveyor

- Establishes of horizontal and vertical project control
- Data management
  - Acquires and validates DTM
  - Converts DTM to exchange format
  - Validates DDM

Changing Role of Surveyor

- Does quality verification as part of the quality assurance program
  - Validates contractor's GPS system is accurate based on project control points
  - Assists construction staff with GPS rover and data management
- Re-measures or validates grade
- Performs as-built surveys for updating the 3D model for asset management

Changing Role of the Inspector

- Performs field work with less support from surveyors
- Checks constructed elements for grade, alignment, or width with fewer stakes available
- Needs additional technology to check stake-less construction

Implementation of Automated Machine Guidance

Project Delivery Directive PD-06

California Department of Transportation

Project Delivery Directive

TO: Project Delivery Employees

Number:	PD-06
References:	*California Public Records Act (CPRA)*
Effective Date:	February 1, 2012
Supersedes:	NEW
Review by:	January 1, 2014

TITLE Sharing of Electronic Files

DIRECTIVE

Electronic copies of certain design information shall be made available to internal and external entities throughout the project delivery process for projects on the State Highway System (SHS). The sharing of electronic files aids in providing information in a cost effective and timely manner that will allow both Caltrans and its partners to deliver projects more efficiently. Therefore, providing these files will aid in improving the overall quality of the project while delivering those projects on time and within budget.

Requests for electronic files will be handled differently based on their category. Requests that do not fall within these three categories are to be handled using the guidance set forth in Deputy Directive DD-79: *California Public Records Act Compliance*.

Category 1. Requests from Project Development Team (PDT) members for electronic files needed to deliver a Caltrans-sponsored project. From Project Initiation Document (PID) to Contract Award, all requests can be made by one PDT member to another. The PDT will freely share the appropriate static or vector files in order to expedite delivery of the project. From Contract Award until Project Closeout, all contractor requests are to go through the Resident Engineer.

Category 2. Requests from prospective bidders for electronic files for use in preparing bids for advertised projects. See Attachment "A" for a list of files to be provided. Bidders do not have a contract with the state for this work, yet providing certain information during the bidding process could lead to better bids. After advertisement, prospective bidders should send all requests in as a "Bidder's Inquiry" through the district construction office, Duty Senior.

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Implementation of Automated Machine Guidance

Project Delivery Directive PD-06

- Established policy for providing electronic files to contractors
- Requires that the following electronic design files must be provided to contractors at the time of project advertisement:

1. Digital terrain model in 3D DGN or LandXML format
2. Roadway design alignments and profiles in LandXML format
3. Cross-sections in 2D DGN and Portable Document Format (pdf)

Implementation of Automated Machine Guidance

CPD 13-10 Implementation of Automated Machine Guidance for Ongoing Projects

February 12, 2013

- Directive provides guidance to the resident engineer regarding the contractor's option to request and obtain from Caltrans the original ground digital terrain model (DTM) and digital design model (DDM), or the electronic design files for the contractor to create a DTM and DDM, so that automated machine guidance (AMG) systems may be used on a project.

Implementation of Automated Machine Guidance

- The next step in implementing AMG is for Caltrans to make AMG the preferred way of constructing projects.
- To accomplish this Caltrans will begin providing the Digital Design Model to contractors at project advertisement in 2015.
- A new specification allowing contractors the option to use AMG will be included in projects with earthwork.

Implementation of Automated Machine Guidance

Section 5-1.26B "Automated Machine Guidance."

- NSSP 5-1.26 "Construction Surveys" now includes Section 5-1.26B "Automated Machine Guidance."
- Specification includes:
  - Definitions
  - How electronic files will be handled
  - What Department Surveys provides to the contractor
  - Contractor Quality Control Plan requirements
  - District option to have contractor provide a GPS rover for use by the Resident Engineer and staff

Implementation of Automated Machine Guidance

The following documents are available for the implementation of AMG (shown on the webpage below):

- Specification 2-1.06B "Supplemental Project Information Electronic Files"
- Specification 5-1.26 "Construction Surveys" which includes Section 5-1.26B "Automated Machine Guidance"
- New form "Grade Checking Report"
- Construction Guidance for Implementing Automated Machine Guidance

Automated Machine Guidance

Specifications and additional information on Automated Machine Guidance are available at:

http://www.dot.ca.gov/hq/construc/amg/

For questions regarding AMG implementation, contact:

- Design - Jesus Mora by email to jesus.mora@dot.ca.gov jesor phone (916) 227-2630.
- Surveys –Mark Turner by email to mark.turner@dot.ca.gov or phone (916) 227-7669.
- Construction - Chuck Suszko by email to chuck.suszko@dot.ca.gov or phone (916) 798-6029

For questions regarding AMG information shown on the above webpage, contact:

- Construction – Jim Cotey by email to jim.cotey@dot.ca.gov or phone (916) 227-5709